basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE/ NATIONAL SENIOR CERTIFICATE

GRADE 12

PHYSICAL SCIENCES: CHEMISTRY (P2)

NOVEMBER 2020(2)

MARKS: 150

TIME: 3 hours

PHYSICAL SCIENCES: Paper 2

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This question paper consists of 16 pages and 4 data sheets.

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GAUTENG

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces on the ANSWER BOOK.
2. This question paper consists of TEN questions. Answer ALL the questions in the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Leave ONE line between two subquestions, e.g. between QUESTION 2.1 and QUESTION 2.2.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your FINAL numerical answers to a minimum of TWO decimal places.
10. Give brief motivations, discussions, etc. where required.
11. You are advised to use the attached DATA SHEETS.
12. Write neatly and legibly.

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QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 E.

1.1 Which ONE of the following is an ALKANE?

A C_6H_8

B C_6H_{10}

C C_6H_{12}

D C_6H_{14} (2)

1.2 Esters are formed by a reaction between two organic compounds, **X** and **Y**, each with a different functional group.

The functional groups of these compounds are:

	Compound X	**Compound Y**
A	Hydroxyl group	Carboxyl group
B	Hydroxyl group	Carbonyl group
C	Hydroxide ion	Carboxyl group
D	Hydroxide ion	Carbonyl group

(2)

1.3 When butane is subjected to high temperatures and pressures, the following reaction takes place:

Butane $\longrightarrow$ methane + **Y**

Which ONE of the following represents **Y**?

A $CHCCH_3$

B CH_2CHCH_3

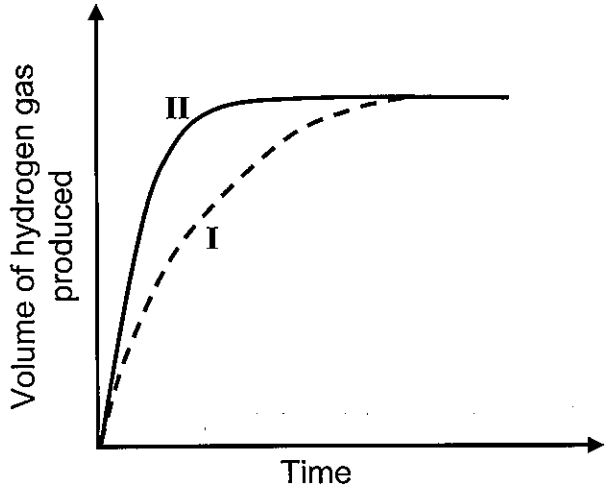
C $CH_3CH_2CH_3$

D $CH_3CHCHCH_3$ (2)

1.4 A hydrochloric acid solution, HCℓ(aq), of concentration 1 mol·dm^{-3} is added to EXCESS POWDERED magnesium at 25 °C.

Curve **I** below represents the volume of hydrogen gas produced during the reaction.

Curve **II** was obtained at different conditions using the SAME VOLUME of hydrochloric acid solution.



Which ONE of the following represents the conditions used to obtain curve **II**?

	STATE OF DIVISION OF Mg	CONCENTRATION OF ACID (mol·dm^{-3})	TEMPERATURE (°C)
A	Ribbon	0,5	25
B	Ribbon	2	25
C	Powder	1	20
D	Powder	1	30

(2)

1.5 In which ONE of the following reactions at equilibrium will the YIELD of the product increase when the VOLUME of the container is increased at constant temperature?

A $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

B $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

C $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

D $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ (2)

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1.6 Which ONE of the following statements is TRUE for an EXOTHERMIC reaction?

A More energy is absorbed than released.

B More energy is released than absorbed.

C Heat of reaction (ΔH) is positive.

D Energy of the products is greater than the energy of the reactants. (2)

1.7 Consider the equation below.

$$H_3PO_4(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + H_2PO_4^-(aq)$$

Which ONE of the following is a conjugate acid-base pair?

A $H_3O^+(aq)$ and $H_2O(\ell)$

B $H_3PO_4(aq)$ and $H_2O(\ell)$

C $H_3PO_4(aq)$ and $H_3O^+(aq)$

D $H_3O^+(aq)$ and $H_2PO_4^-(aq)$ (2)

1.8 Consider the balanced equation for the reaction below:

$$2Cr^{2+}(aq) + Sn^{4+}(aq) \rightarrow 2Cr^{3+}(aq) + Sn^{2+}(aq)$$

The OXIDISING AGENT is:

A $Cr^{2+}(aq)$

B $Cr^{3+}(aq)$

C $Sn^{2+}(aq)$

D $Sn^{4+}(aq)$ (2)

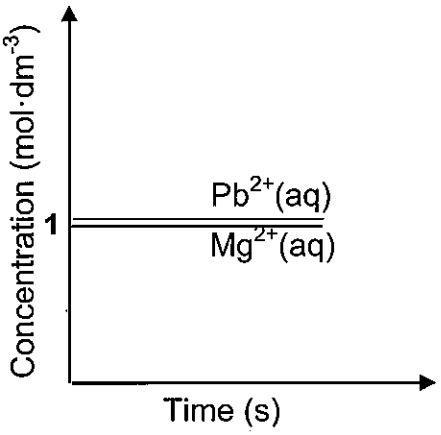
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1.9 An electrochemical cell is set up at standard conditions. The cell notation for the cell is given below.

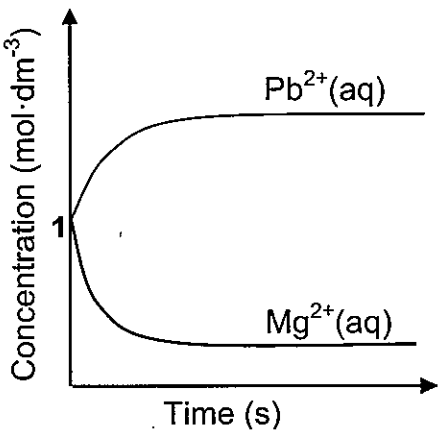
$$Mg(s) \mid Mg^{2+}(aq) \parallel Pb^{2+}(aq) \mid Pb(s)$$

The cell is now connected in a circuit. Which ONE of the graphs below BEST represents the concentrations of the electrolytes after a long time?

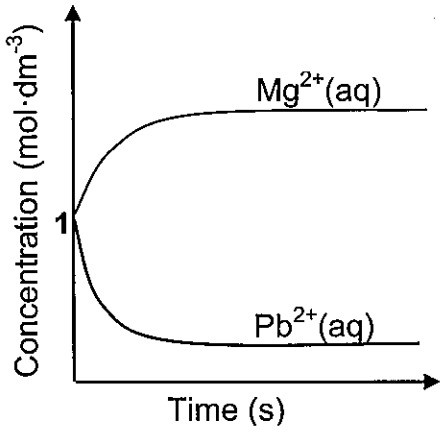
A



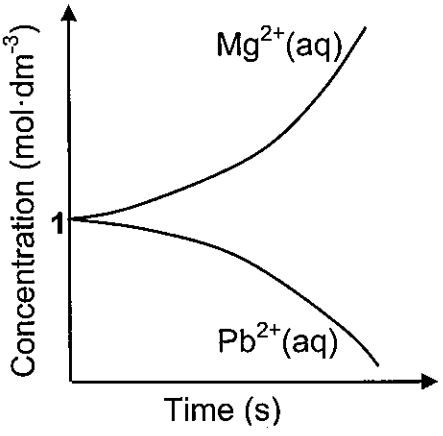
B



C



D



(2)

1.10 Two 50 kg bags, containing fertilisers **R** and **S** respectively, are labelled as follows:

Fertiliser **R**: 3 : 1 : 5 (20)
Fertiliser **S**: 1 : 2 : 6 (20)

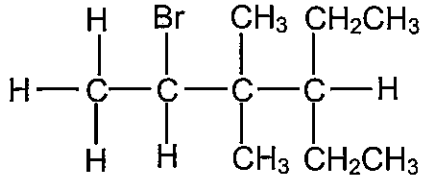
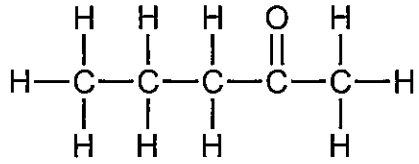
Identify the fertiliser(s) most suitable for healthy leaf growth and healthy root growth.

	LEAF GROWTH	ROOT GROWTH
A	R	R
B	S	R
C	R	S
D	S	S

(2)
[20]

QUESTION 2 (Start on a new page.)

The letters **A** to **E** in the table below represent five organic compounds.

A		**B**	C_xH_y
C		**D**	$CH_3(CH_2)_2CH(OH)CH_2CH_3$
E	$CH_3CH_2CH_2CH_2CH_2CH_2CHCH_2$		

2.1 Write down the LETTER that represents EACH of the following:

2.1.1 A ketone (1)

2.1.2 A hydrocarbon (1)

2.1.3 An alkene (1)

2.2 Write down the:

2.2.1 IUPAC name of compound **A** (3)

2.2.2 STRUCTURAL FORMULA of compound **D** (2)

2.2.3 IUPAC name of the STRAIGHT CHAIN FUNCTIONAL ISOMER of compound **C** (2)

2.3 Compound **B** is a straight chain compound that undergoes the following exothermic reaction:

$$2C_xH_y + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

2.3.1 Besides being exothermic, what type of reaction is represented above? (1)

2.3.2 Determine the MOLECULAR FORMULA of compound **B**. (2)

The reaction above takes place in a closed container at a constant temperature higher than 100 °C and at constant pressure.

2.3.3 Calculate the TOTAL VOLUME of gas formed in the container when 50 cm^3 of C_xH_y reacts completely with oxygen. (3)

[16]

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QUESTION 3 (Start on a new page.)

Compounds **A**, **B** and **C** are used to investigate a factor which influences the boiling points of organic compounds. The results of the investigation are given in the table below.

	COMPOUND	BOILING POINT (°C)
A	Butan-1-ol	117
B	Butan-2-ol	100
C	2-methylpropan-2-ol	82

3.1 Is this a fair investigation? Choose from YES or NO. (1)

3.2 Give a reason for the answer to QUESTION 3.1. (1)

3.3 Fully explain the difference in the boiling points of compounds **B** and **C**. (3)

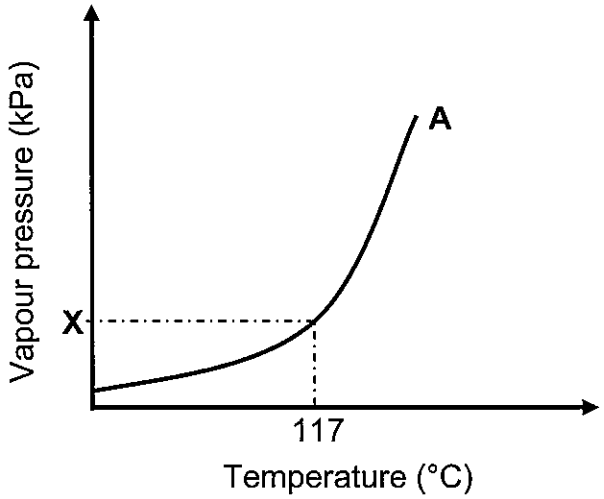
3.4 Define the term *positional isomer*. (2)

3.5 From compounds **A**, **B** and **C**, choose the letter(s) that represent(s) EACH of the following:

3.5.1 Positional isomers (1)

3.5.2 A tertiary alcohol
Give a reason for the answer. (2)

3.6 The graph below represents the relationship between vapour pressure and temperature for compound **A** (butan-1-ol).



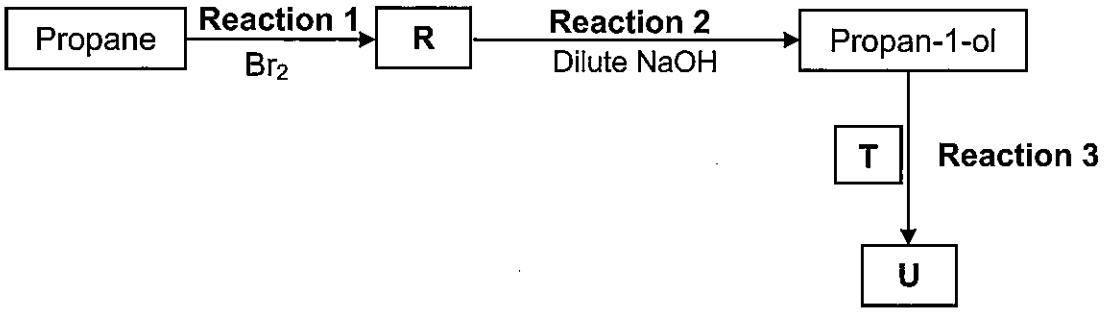
3.6.1 Write down the value of **X**. (1)

3.6.2 Redraw the graph above in the ANSWER BOOK. On the same set of axes, sketch the curve that will be obtained for compound **C**. Clearly label the curves **A** and **C**. Indicate the relevant boiling point for compound **C** on the graph. (2)
[13]

QUESTION 4 (Start on a new page.)

4.1 The flow diagram below shows various organic reactions using propane as starting reactant. **R**, **T** and **U** represent different organic compounds.

Compound **T** is a CARBOXYLIC ACID and compound **U** is a FUNCTIONAL ISOMER of pentanoic acid.



Write down the NAME of the type of reaction represented by:

4.1.1 Reaction **1** (1)

4.1.2 Reaction **2** (1)

Consider **reaction 1** and **reaction 2**.

4.1.3 Write down the IUPAC name of compound **R**. (2)

Reaction 3 takes place in the presence of a catalyst and heat.

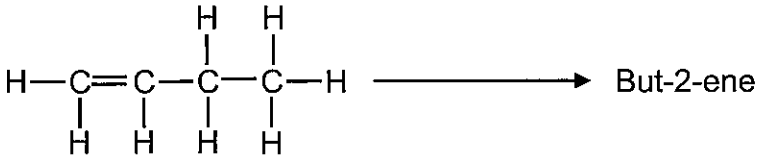
Write down the:

4.1.4 NAME or FORMULA of the catalyst (1)

4.1.5 IUPAC name of compound **T** (2)

4.1.6 STRUCTURAL FORMULA of compound **U** (2)

4.2 A laboratory technician wants to prepare but-2-ene using but-1-ene as starting reagent, as shown below.



The following chemicals are available in the laboratory:

concentrated H_2SO_4	H_2O	concentrated NaOH

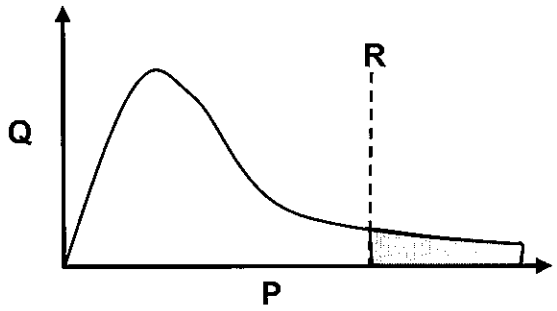
Select the chemicals required to design this preparation from the list above.

For EACH step of the preparation, write down the balanced equation, using STRUCTURAL FORMULAE for all organic compounds. Indicate the chemicals needed in each step. (6)

[15]

QUESTION 5 (Start on a new page.)

5.1 Study the Maxwell-Boltzmann distribution curve for a certain reaction below.



P and **Q** are the labels of the axes. What quantity is represented by:

5.1.1 **P** (1)

5.1.2 **Q** (1)

5.2 Line **R** represents the minimum energy required for the reaction to take place.

5.2.1 Write down the term for the underlined phrase. (1)

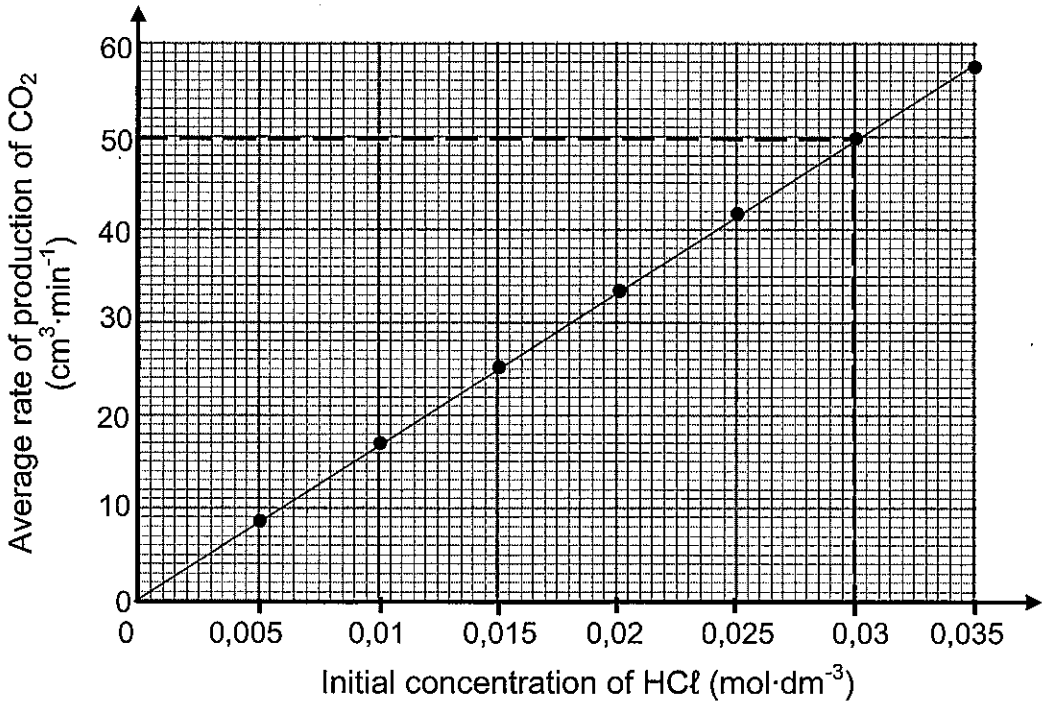
5.2.2 How will the shaded area on the graph be affected when a catalyst is added? Choose from INCREASE, DECREASE or REMAINS THE SAME. (1)

5.3 Use the collision theory to explain how a catalyst influences the rate of reaction. (4)

5.4 The reaction between POWDERED calcium carbonate, $CaCO_3(s)$, and EXCESS hydrochloric acid, $HC\ell(aq)$, is used to investigate reaction rate at 25 °C. The balanced equation for the reaction is:

$$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

Several experiments are conducted using the same mass of IMPURE calcium carbonate and different initial concentrations of dilute hydrochloric acid. The graph below represents the results obtained. Assume that the impurities do not react.



For this investigation, write down a:

5.4.1 Controlled variable (1)

5.4.2 Conclusion (2)

The $CaCO_3(s)$ in 6 g of the impure sample reacts completely with 0,03 $mol \cdot dm^{-3}$ $HC\ell(aq)$ in 26 minutes.

5.4.3 Use the information in the graph to calculate the percentage purity of the calcium carbonate. Assume that the molar gas volume at 25 °C is 24 000 cm^3. (6)

[17]

QUESTION 6 (Start on a new page.)

Steam, $H_2O(g)$, reacts with hot carbon, C(s), at 1 000 °C according to the following balanced equation:

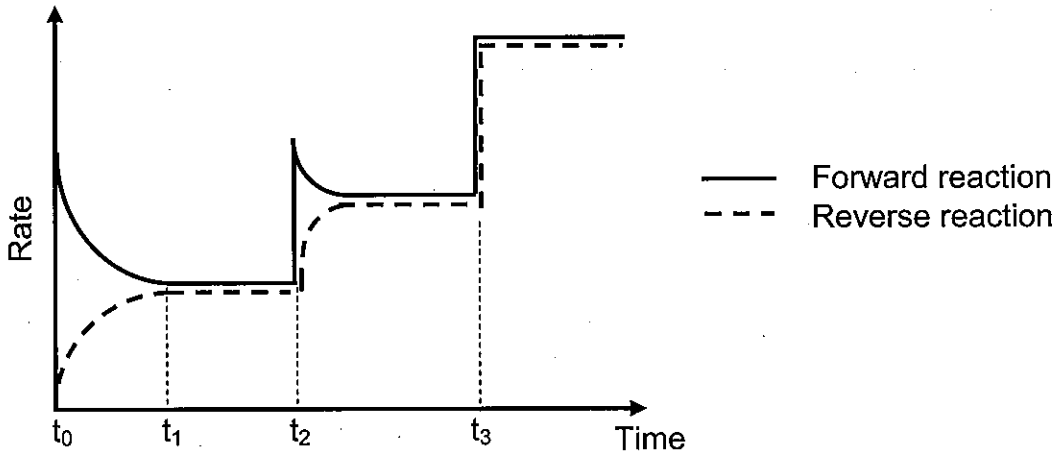
$$2H_2O(g) + C(s) \rightleftharpoons 2H_2(g) + CO_2(g)$$

Initially, 36 g of steam and a certain amount of carbon were placed in a 2 dm^3 sealed container and allowed to react. At equilibrium it was found that the amount of carbon changed by 0,225 mol.

6.1 Define the term *dynamic equilibrium*. (2)

6.2 Calculate the equilibrium constant, K_c, for the reaction at 1 000 °C. (8)

6.3 The graph shows how the rates of the forward and reverse reactions change with time.



6.3.1 Give a reason why the rate of the forward reaction decreases between t_0 and t_1. (1)

6.3.2 What change was made to the equilibrium mixture at t_3? (1)

At time t_2, the temperature of the system is increased.

6.3.3 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? (1)

6.3.4 Refer to Le Chatelier's principle to explain the answer to QUESTION 6.3.3. (2)
[15]

QUESTION 7 (Start on a new page.)

Two beakers, **A** and **B**, contain strong bases.

Beaker **A**: 500 cm^3 of barium hydroxide, $Ba(OH)_2(aq)$ of unknown concentration **X**

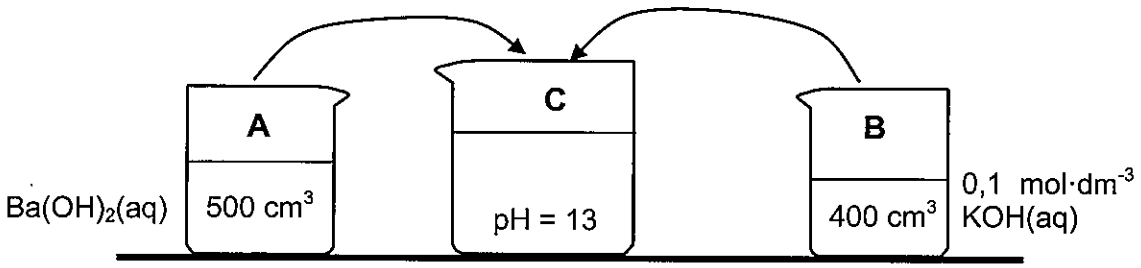
Beaker **B**: 400 cm^3 of potassium hydroxide, KOH(aq) of concentration 0,1 $mol \cdot dm^{-3}$

7.1 Define a *base* according to the Arrhenius theory. (2)

7.2 Calculate the number of moles of hydroxide ions (OH^-) in beaker **B**. (2)

7.3 The contents of beakers **A** and **B** are added together in beaker **C**. The solution in beaker **C** has a pH of 13.

Assume that the volumes are additive and that the temperature of the solutions is 25 °C.



7.3.1 Calculate the concentration, **X**, of the $Ba(OH)_2$ in beaker **A**. (8)

The solution in beaker **C** is titrated with ethanoic acid. It was found that 15 cm^3 of the solution neutralises 30 cm^3 of the acid.

The balanced equation for the reaction is:

$$CH_3COOH(aq) + OH^-(aq) \rightarrow CH_3COO^-(aq) + H_2O(\ell)$$

7.3.2 Is ethanoic acid, $CH_3COOH(aq)$, a WEAK acid or a STRONG acid?

Give a reason for the answer. (2)

7.3.3 Calculate the concentration of the ethanoic acid. (4)

[18]

QUESTION 8 (Start on a new page.)

A galvanic cell at standard conditions is represented by the cell notation below. **X** and **Y** are unknown electrodes.

$$\mathbf{X} \mid Zn^{2+}(aq) \parallel Fe^{3+}(aq) , Fe^{2+}(aq) \mid \mathbf{Y}$$

8.1 Write down the NAME or FORMULA of:

8.1.1 Electrode **X** (1)

8.1.2 Electrode **Y** (1)

8.1.3 The oxidising agent (1)

8.2 Write down:

8.2.1 ONE function of electrode **Y** (1)

8.2.2 The half-reaction that takes place at electrode **Y** (2)

8.2.3 The net (overall) equation for the cell reaction that takes place in this cell (3)

8.3 Calculate the initial emf of this cell. (4)

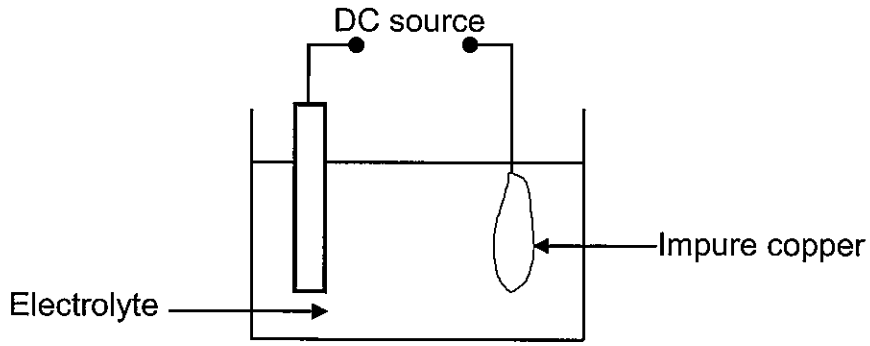
8.4 How will the initial emf of the cell be affected when the concentration of the iron(III) ions is changed to 0,6 $mol \cdot dm^{-3}$? Choose from INCREASES, DECREASES or REMAINS THE SAME. (1)

[14]

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QUESTION 9 (Start on a new page.)

The simplified diagram below represents an electrochemical cell used for the purification of copper. The impure copper contains small amounts of silver (Ag) and zinc (Zn) as the only impurities.



9.1 Define the term *electrolysis*. (2)

9.2 Write down the NAME or FORMULA of TWO positive ions present in the electrolyte. (2)

9.3 Write down the half-reaction that takes place at the cathode. (2)

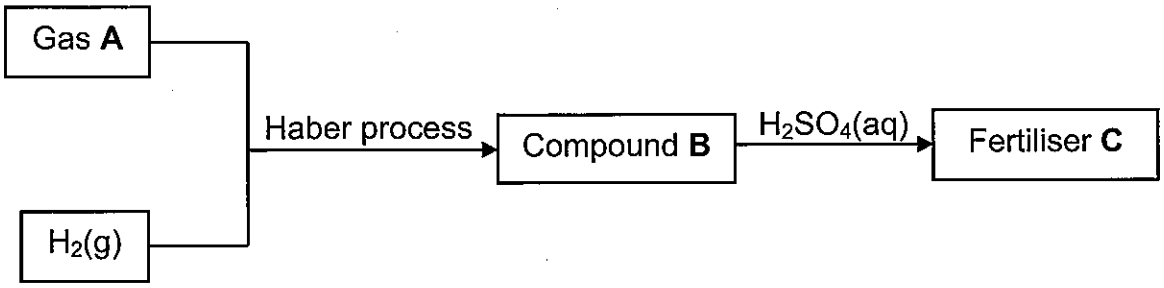
9.4 Refer to the Table of Standard Reduction Potentials and explain why the purified copper will NOT contain any zinc. (3)

9.5 Calculate the maximum mass of Cu formed if 0,6 moles of electrons are transferred. (3)
[12]

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QUESTION 10 (Start on a new page.)

10.1 The flow diagram below shows processes involved in the production of fertiliser **C**.



Write down the NAME or FORMULA of:

10.1.1 Gas **A** (1)

10.1.2 The catalyst used in the Haber process (1)

10.1.3 Compound **B** (1)

Write down the:

10.1.4 Name of the process used to produce gas **A** (1)

10.1.5 Balanced equation for the formation of fertiliser **C** (3)

10.2 A 40 kg bag of fertiliser contains 65% filler. The mass of the nutrients in the bag is shown in the table below.

NUTRIENTS	MASS (kg)
Nitrogen	**x**
Phosphorous	2**x**
Potassium	5

Calculate the NPK ratio of the fertiliser. (3)
[10]

TOTAL: 150

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DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 2 (CHEMIE)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^θ	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^θ	273 K
Charge on electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a v_a}{c_b v_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ / $E^\theta_{sel} = E^\theta_{katode} - E^\theta_{anode}$ or/*of* $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ / $E^\theta_{sel} = E^\theta_{reduksie} - E^\theta_{oksidasie}$ or/*of* $E^\theta_{cell} = E^\theta_{oxidisingagent} - E^\theta_{reducingagent}$ / $E^\theta_{sel} = E^\theta_{oksideermiddel} - E^\theta_{reduseermiddel}$	

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TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

KEY/*SLEUTEL*

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit

29
1,9 Cu
63,5

Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

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TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD-REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*			E^{θ} (V)
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+ 0,68
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+ 0,54
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+ 0,14
$2H^+ + 2e^-$	**$\rightleftharpoons$**	**$H_2(g)$**	**0,00**
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	– 0,06
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	– 0,13
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	– 0,14
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	– 0,27
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	– 0,28
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	– 0,40
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	– 0,41
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	– 0,44
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	– 0,74
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	– 0,76
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	– 0,83
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	– 0,91
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	– 1,18
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	– 1,66
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	– 2,36
$Na^+ + e^-$	$\rightleftharpoons$	Na	– 2,71
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	– 2,87
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	– 2,89
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	– 2,90
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	- 2,92
$K^+ + e^-$	$\rightleftharpoons$	K	– 2,93
$Li^+ + e^-$	$\rightleftharpoons$	Li	– 3,05

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TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD-REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	$\rightleftharpoons$	Li	− 3,05
$K^+ + e^-$	$\rightleftharpoons$	K	− 2,93
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	− 2,92
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	− 2,90
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	− 2,89
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	− 2,87
$Na^+ + e^-$	$\rightleftharpoons$	Na	− 2,71
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	− 2,36
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	− 1,18
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	− 0,91
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	− 0,76
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	− 0,74
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	− 0,44
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	− 0,40
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	− 0,28
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	− 0,27
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	− 0,14
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	− 0,13
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	− 0,06
$2H^+ + 2e^-$	**$\rightleftharpoons$**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+ 0,52
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87

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